Tesco Controls, Inc.
Reduced Voltage Solid State_Motor Control Center
L2000 PLC with Reactive Air

TESCO CONTROLS, INC.
An Employee-Owned Company

MOTOR CONTROL CENTER SPECIFICATIONS

Motor Control Center shall be an integrated system consisting of main breaker, disconnect switches, pump breakers, combination motor starters with controls, distribution transformer, panelboard programmable pump controller, wetwell level monitors, power supplies, battery back up, relays and other automatic controls and devices. The pump controller and instrumentation shall be furnished as an integral part of the motor control center by the motor control center manufacturer. The completed motor control center shall contain a U/L 508 label. The enclosure shall be rated NEMA 1, U.L. labeled Industrial Control, and meet all the requirements of local, state, and county ordinances. Each motor control section shall have 1 1/2" x 1 1/2" x 1/4" minimum angle iron frame base. Each cubicle shall be individually barriered with wireways on both sides, line on left and load on right. All connections shall be front accessible. All hinges and screws shall be stainless steel. Dead front latches shall be 1/4 turn adjustable latches with 1/8" thick latching dog and knurled knob. Screw type fasteners will not be acceptable. The complete motor control center shall be painted with a polyester dry powder, electrostatically applied and baked on at 380 degree Fahrenheit to provide a corrosion resistive polyporc finish. Interior color including front and back of all swing out doors, separation barriers and mounting backpans shall be white. The painting process shall include five stages of metal preparation using dip tanks as follows: 1) Alkaline cleaner, 2) Clear water rinse, 3) Iron phosphate application, 4) Clear water rinse, and 5) Inhibitive rinse to seal phosphated surfaces. Exterior color shall be ANSI 61 gray, interior surfaces shall be white.

Horizontal bussing shall be provided. Bussing shall be copper with silver plated joints by electrolysis method to 0.0002 inches. Ampacity shall be calculated on 1000 amps/square inch of cross sectional area. Bracing shall be for 50,000 AIC minimum.

All miscellaneous control and instrument wiring shall be protected by fuses or circuit breakers. Wiring shall be neatly bundled or run in plastic wireways. Wires shall be color coded per U.L. standards and shall be 600 volt MTW or THHN with 19 strands of copper. All wires shall be permanently numbered with Brady slip clip wire markers. Terminal strips shall be numbered to match wire numbers. Common wires shall be of a common color and number throughout the system. All devices shall be permanently labeled. All door mounted devices shall be labeled with black and white, screw fastened, engraved, plastic nameplates. Stick on labels, wire fasteners, or wire numbers are not acceptable. All wiring shall be to NEMA Class II C requirements. Complete wiring diagrams shall be provided drawn with computer aided design (CAD) techniques. All components associated with a particular compartment's function shall be mounted in that compartment; i.e. control relays, motor starters, etc. shall be mounted in the control section compartment. Spacing of components shall be in accordance with U.L. standards.

Where required, ventilation shall be provided through louvers with bug screens. Transformers above 5 KVA shall be ventilated by 6 square inches of opening for each KVA.

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Each compartment shall have a space heater and a thermostat.

Motor Control

Provide each motor with a suitable controller and devices that will perform the functions as specified for their respective motors. Controllers shall conform to the applicable requirements of NEMA ICS, ANSI C19.1, the NEC, and UL. Anticipated horsepower ratings are shown on the contract documents. This information is for guidance only and does not limit the equipment size. When motors furnished differ from the expected ratings indicated, make the necessary adjustments to wiring, conduit, disconnect devices, motor starters, branch circuit protection, and other affected material or equipment to accommodate the motors actually installed, at no additional cost to the Owner.

Each motor control system shall be equipped with a hand-off-auto control switch, indicating lights, elapsed time meter, ammeter, motor starter, control transformer with primary fuses and secondary control power fuse.

Control switches and indicating lights shall be U.L. listed oil-tight devices rated heavy duty. Provide Idec, Westinghouse, or equal.

Motor starters shall be NEMA rated with an electrically held contractor and a single reset, 3 phase, overload relay with a normally closed holding contact and a normally open isolated contact for overload alarm. Each overload shall be ambient compensated and shall trip on 600% of full load current in less than 6 seconds. Each motor starter Size 3 and larger shall be furnished with a minimum of 4 auxiliary contacts and provisions for adding 2 more. Auxiliary contacts shall be convertible, in the field, from normally open to normally closed. Each overload relay shall have a test trip push-button built-in and a adjustable calibrated trip with indicating dial. There shall be an unbreakable steel operator, with insulated plastic foot (for safety) through the front door for manual reset. Provide Westinghouse A201, Allen Bradley 100, or equal.

Control power transformers shall be sized as shown on the plans, minimum size shall be 100VA where not designated. Provide Micron, G.E., or equal.

Time on delay relays for staggered start. Time delay relays are to delay the pump motors from starting upon resumption of service power, such that only one motor can be started at a time. Time delay relays shall be furnished for pump fail indication, set to interface with limit switches and ride through normal starting time.

Ammeters with phase to phase/phase to ground switch shall be provided for each motor. Appropriately sized current transformers shall be installed. Ammeters with switch shall be mounted on the corresponding motor starter MCC cubicle door.

Terminal and Distribution Blocks

Distribution blocks shall be furnished and installed as required for "fan-out" of control power and other 120V sources within the enclosure. The blocks shall be rated 300V at a minimum of 20 amperes and sized for the conductors served. Distribution blocks shall be similar to Square D, Connectron NFT, or equal.

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Circuit Breakers

All 480 volt circuit breakers shall have interrupting capacities at 14,000 amperes. All 120 volt breakers shall be rated 10,000 amperes interrupting capacity. Circuit breakers shall be of the indicating type, providing ON, OFF and TRIPPED positions of the operating handle. Circuit breakers shall be quick-make, quick-break, with a thermal-magnetic action, except when protecting motor feeders where motor circuit protector (MCP) breakers may be used. Circuit breakers shall be the bolted on type. The use of tandem or dual circuit breakers in a normal single- pole space to provide the number of poles or spaces specified is not acceptable. All multiple-pole circuit breakers shall be designed so that an overload on one pole automatically causes all poles to open. Circuit breakers shall meet the requirements of UL and NEMA AB I. Breakers shall be Westinghouse EHD, MCP, or equal. All circuit breakers shall be heavy duty molded case circuit breakers conforming to Federal specification W-C-375B and shall be UL listed. A button shall be provided on the cover for mechanically tripping the breaker.

Name Plates

Nameplates shall be black phenolic with white lettering. Nameplates shall be stainless steel screw mounted. Glue type will not be acceptable.

Panelboard

Panelboard shall be circuit breaker type custom constructed to utilize minimum enclosure space with breakers as shown. Circuit breakers shall be bolted on type. The panelboard shall be furnished with phenolic nameplates. The panelboard transformer shall be dry type construction sized as shown on the plans with primary breaker protection. The panelboard transformer shall be a Jefferson 211, G.E., or equal.

Panel Lights

Furnish and install push-to-test lights to indicate status and alarm conditions locally as shown on drawings. Engraved phenolic nameplates shall specify each light's function. Lights shall be wired as shown on drawings. Panel lights shall be full voltage IDEC ALD or equal.

Push Buttons and Selector Switches

Push-buttons, and selector switches, for non hazardous indoor dry locations shall be U/L listed oil-tight type, Westinghouse Type OT, Idec ASN, General Electric Type CR 240, Square D Class 9001, or equal. These devices shall have individual, extra large nameplates indicating their specific function.

Receptacles, Duplex

Receptacles shall be of specification grade and of NEMA configuration and rated 2 pole, 3 wire grounding, 20 amperes, 125 volts, such as Pass & Seymour 5252, Leviton 6898, Bryant 5252, or equal. Contact arrangement shall be such that contact is made on two sides of each inserted blade. Bases shall be of ivory phenolic composition. Wire terminals shall be suitable for 10 AWG wire and shall be screw type. Receptacles shall be UL listed. The receptacles shall have corrosion resistant conducting parts of nickel-plated brass and other metal parts of stainless steel. All external and dead front receptacles shall be installed on ground fault interrupter circuits "GFCI".

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Relays, Controls

Control relays shall be Potter and Brumfield KU, Square D Type KU, Idec Type RH or equal. Two form-C contacts (minimum) shall be provided on each relay. Provide relay energized neon lamp (inside relay case).

Relays, Power Fail

The power fail relay shall continuously monitor the three phases for power loss, low voltage, phase loss, phase reversal and have automatic reset. The power fail monitor shall have a drop-out voltage adjustment and a failure indicating LED. Provide Diversified model SLA, or equal.

Relays, Time Delay

Time delay relays shall be solid state relays with a timer adjustable over the range 1 to 60 seconds unless other ranges are indicated or required. Provide LED relay energized indicator lamp. Time delay relays shall be IDEC RTE, Agastat STA, or equal.

REDUCED VOLTAGE SOLID STATE SOFT STARTER SPECIFICATION

GENERAL REQUIREMENTS

Description

SCOPE: The supplier shall provide and install complete and ready for use an Engineered Reduced Voltage Solid State (RVSS) Soft Starter system

1. Reduced Voltage Solid State Starter(s):
2. Microprocessor based Programmable Controller:
3. System software:
4. Circuit breakers and other appurtenances:
5. Enclosures:
6. Ventilation / Air Conditioning
7. Personnel Protection System (PPS):
8. Startup, Operator Training and Testing:

Quality Assurance

Acceptable Suppliers: The system supplier shall be regularly engaged in the production of RVSS control equipment and shall be able to demonstrate such experience for a period of not less than five (5) years.

Source Quality Control

1. After equipment is completely assembled, the supplier shall perform shop test for operating conditions, circuit continuity, high potential, and other standard tests for 600V class equipment.

2. Perform dielectric tests on all circuits, including power and control, in accordance with NEMA procedures in "Tests for Industrial Control Systems"

3. Certification: The system shall bear an UL or ETL label.

The system shall meet all applicable National, State, County and local codes and ordinances.

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Submittals

Shop Drawings and Product Data

1. Submit outline Drawings including plan, front and sectional or side views and dimensional data, schematics, wiring diagrams and operation and maintenance manuals sufficiently complete to fully describe the system to be provided. As a minimum the following shall be provided:

a. Projected floor space required for equipment
b. Absolute minimum working space required at front, rear and sides of equipment.
c. Equipment height
d. Equipment weight
e. Sill and anchor bolt locations

2. Sufficient data to verify compliance with specifications.
3. Wiring diagrams of all units including wire and terminal identification and numbering system
4. Name of manufacturer:, Allen Bradley SMC Dialog Plus or Pre-Approved Equal

All shop drawings to be prepared utilizing Computer Aided Design techniques (CAD) and be maintained on floppy disk by the supplier for a period of not less than 10 years.

Product Delivery, Storage and Handling

Ship anchor materials ahead of scheduled equipment delivery permitting installation before concrete is placed.

During construction protect all electrical equipment insulation against absorption of moisture, metallic components against corrosion, by strip heaters, lamps, plastic wrapping, or other suitable means.

1. Provide temporary power, if needed, for this use
2. Provide protection immediately upon receipt of equipment and maintain continuously

Reduced Solid State Starter(s)

General: The RVSS(s) is a critical component of the proposed system. Past performance of various manufacturers has revealed substantial differences in function, serviceability, and reliability. Products deemed acceptable for this application are Allen Bradley SMC Dialog Plus or Pre-approved Equal. The supplier shall submit for approval, at least 10 days prior to bid, any alternative RVSS equipment proposed for this project.

1. The RVSS(s) shall be of the latest technology.
2. It shall be designed for variable torque or constant torque loads requiring a control that maintains a process variable (level, flow, pressure, etc.) for motors such as:

a. Centrifugal pumps
b. Turbine pumps
c. Centrifugal fans

3. The RVSS shall be available from a single manufacturer in the horsepower range of 0.5 to 800 HP.
4. The RVSS shall incorporate a dymamic Phase Rebalance feature to compensate for voltage unbalance by automatically adjusting the voltage output to balance the three-phase currents drawn by by motor.
5. RVSS's which utilize tradisional voltage unbalance protection are unacceptable.

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6. Environmental operating conditions:
a. Altitude - up to 3,300 feet
b. Ambient temperature - 32 to 122 Fahrenheit
c. Humidity - up to 95% non-condensing

7. Input signal
a. 100-240V AC
b. 24V AC
c. 24V DC

8. Input line voltage regulation: 200-480V AC, 200-600V AC (-15%, +10%)

9. Diagnostic LCD Display
a. Power loss - indicates whenever power is lost or the capacitors are not fully charged.
b. Overload indicator - will display when a RVSS is supplying more current than the programmable preset to the load.
c. Jam detection - displays to inform of motor jam according to the percentage of the motor's full load current rating after the programmable allotted time.
d. Over-voltage - will show when the RVSS has tripped due to either an overhauling load (regenerative voltage) or an extremely high input voltage.
e. Under-voltage- displays when the RVSS has tripped due to an input voltage below the adjustable required voltage percentage level for more than programmable allotted time.
f. Underload - shows when the RVSS has tripped due to sudden drop in current according to the adjustable full load current rating percentage of the programmable allotted time.
g. Over-temperature - indicates when the RVSS has tripped due to a transistor heat- sink over-temperature caused by insufficient cooling.
h. Voltage Unbalance - displays and halts motor due to the programmable percentage of the voltage supply magnitudes in conjunction with the rotational relationship of the involved phases.

10. Thermal overload relay and trip
a. Monitor motor current
b. Electronic type, adjustable
c. Compensation for reduced motor cooling at reduced speeds.
d. Standard motor overload protection shall not be acceptable

11. Manual push-button and automatic reset of a RVSS trip shall be provided.
a. Automatic reset

1) Upon a fault trip the RVSS shall automatically reset the drive of a programmable set number of attempts (usually 3) before locking the starter off line and posting a RVSS failure alarm.
2) Upon a successful reset, the RVSS shall return to normal operation.

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3) After the set number of resets and without the drive successfully restarting, the trip shall lock out and a visual indication of the fault shall be annunciated.
4) When the drive is locked out after its automatic reset attempts the operator shall be able to reset the count register and drive by a door mounted manual reset push- button.

Other Materials
Circuit Breakers

1. Ratings at 600V
    a. 100 and 225 amp frame
        1) Interrupting: 14,000 amps symmetrical
        2) Non interchangeable trip
2. Three-pole single throw, 600V molded case air circuit breakers
3. Manually operated with quick-make, quick-break, trip free toggle mechanism
4. Bimetallic thermal elements
    a. Designed to withstand sustained overloads and short circuit currents without damage or affecting calibration
    b. Inverse time characteristic
    c. Trip at 125% of trip current rating
5. Arc quenching devices
6. Main contacts
    a. Silver plated
    b. Carry rated current without exceeding UL temperature limits
7. Operating handle to indicate automatic tripping
8. Door interlock for supply circuit breakers
    a. Interlocked to prevent opening access door when breaker is closed
    b. External operating handle with provisions for up to 3 padlocks.
9. Labeled as service entrance equipment where the Drawings indicate the breaker is to be used as service entrance disconnect

Starters and Contactors
1. Contactors
a. 120V coil
b. Three-phase, 60 Hz, 600V
c. Eight hour current rating in accordance with NEMA
d. Reversing and multi-speed starters: Electrically and mechanically interlocked.

Spare interlock contacts
a. In addition to the interlock contacts indicated on the Drawings, provide two spare N.O. and two spare N.C.; or two spare convertible, interlocking contacts.
b. Wire all spare contacts to terminal blocks.

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Control power transformer

1. Dry type
2. Ratings as indicated on Drawings
3. Two full capacity taps, minimum for 5 KVA or larger

Lighting Panels

1. Panelboard with main lugs, buses, bolted or plug-in thermal magnetic breakers and provisions for breakers in the sizes, quantities, and poles indicated on the Drawings
2. Multiple pole breakers: Common trip
3. Ground fault interrupters: 5 mA sensitivity
4. Interrupting rating

a. 10,000 amp symmetrical, minimum

b. Coordinated with control center short circuit rating and transformer impedance

5. Provide door in front cover with a typewriter circuit directory

Relays and Timers

1. 120 V, 60 Hz coils for continuous duty in 40 C ambient
2. 10 ampere, 120 V, AC contacts
3. Contacts, actions, ranges, and settings as indicated on Drawings
4. Auxiliary relays

a. Machine tool type, 300V minimum

b. Plastic enclosed plug in type

c. Neon "ON" indicator

Time delay relays

a. Pneumatic timing utilizing pressure- controlled orifice

b. Time calibrated dial head adjustment

c. Subpanel mounted

Pilot Devices

1. Heavy-duty oil tight, NEMA 13
2. Door mounted
3. Contacts and lamp lens colors as indicated on the Drawings
4. Escutcheon type legend and plate for each pilot device

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Enclosures and Manufacture

Vertical Sections

1. Freestanding, vertical sections and special freestanding instrument sections bolted together to form a single dead front panel assembly containing.

a. Pull sections
b. Circuit breakers
c. Contactors
d. Transformers
e. Isolation Transformer if required
f. Reduced Voltage Solid State unit
g. Relays, indicating lights, run time meter and other control components as shown on contract drawings
h. Local-Off-Remote selector switch
i. Wiring
j. Busing
k. Panelboards
l. Process Controller
m. Other devices shown on the Contract Drawings or specified

Bussing

1. Copper phase, ground, and neutral horizontal busses
2. Tin or silver plated joints
3. 1000 amps/sq. in. of cross section area
4. Brace for 50,000 amps symmetrical, minimum

5. Bus supports

a. High dielectric strength
b. Low moisture absorbency
c. High impact resistant
d. Ample creepage distance between phases

Wallmount Units

1. Wallmounted RVSS unit to form a single dead front panel assembly containing.

a. Isolation Transformer
b. Reduced Voltage Solid State unit
c. Relays, indicating lights, run time meter and other control components as shown on contract drawings.
d. Local-Off-Remote selector switch
e. Wiring
f. Busing
g. Other devices shown on the Contract Drawings or specified

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Terminals

1. Provide suitable solderless terminals or lugs for connection of all incoming and outgoing circuits
2. Provide terminals for control cables shown by the one-line and schematic drawings as entering control center without connection to internal devices

Fabrication

1. Structure shall be fabricated from 12 gauge hot- dipped galvanized sheet steel.
2. NEMA 1 or NEMA 3R construction, as specified
3. Each section to have 1-1/2"X1-1/2"X1/4" minimum hot-dipped galvanized sheet steel angle base as required
4. Front accessibility
5. Each cubicle individually barriered
7. Stainless steel hinges and screws
8. All Dead front latches are 1/4 turn adjustable with 1/8" thick latching dog and knurled knob
9. Concrete base with anchor bolts to meet applicable seismic requirements shall beprovided as required

Outdoor Weather-wrap NEMA 3R

1. Fabricated from minimum 12 gauge hot-dipped galvanized sheet steel
2. Individual front door shall not exceed 40 inches in width
3. Door latching mechanism shall utilize a three point design, pad lock provisions included
4. Side clearance form internal MCC sections shall be 3 inch minimum
5. Front clearance from internal MCC sections shall be 6 inches minimum
6. Front clearance from internal switchboard sections shall be 11 inches minimum
7. Lifting eyes shall be provided 3/8 inch minimum

Finish

1. Exterior color, ANSI 61 gray or as specified
2. Interior color white
3. Electrostatically applied polyethylene dry powder baked at 380 deg. F.

4. Metal shall be chemically prepared prior to painting using five step preparation process consisting of:

a. Alkaline cleaner
b. Clear water rinse
c. Iron phosphate application
d. Clear water rinse
e. Inhibitive rinse

Wiring

1. Protect with fuses or circuit breakers
2. Bundled with plastic ties or wrap or run in plastic wire ways
3. Color coded

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4. 600 Volt, 19 strand MTW or THHN
5. Number each wire with Brady slip clip markers or equal according to shop drawings.
6. Number all terminal strips according to shop drawings
7. Common wires to be of same number 4 and color throughout
8. Label front panel devices with engraved, laminated nameplates fastened with at least 2 screws
9. Label rear panel devices
10. NEMA class IIC wiring
11. All components associated with a particular compartments function to be mounted in that compartment

Ventilation

1. Expanded metal openings with bug screens
2. RVSS'S to be forced air fan cooled to limit temperatures to RVSS manufacturer's specifications
3. Provide 6 sq. in. ventilation opening per KVA for any transformer above 5 KVA

Air Conditioner: In outdoor, NEMA 3R, installations shall be furnished with appropriate Air Conditioning A.C. units

1. A.C. shall be solid state design
2. Sized to maintain internal temperature within VFD manufacturers standards
3. Closed-loop design
4. Suitable for outdoor applications
5. Unit shall be as manufactured by McClean Midwest, Slimboy series or approved equal

Personnel Protection System

1. Integrated system including enclosure, electrical and process controller
2. Enclosure shall be compartmentalized with separate isolated compartments for RVSS and associated appurtenances.
3. Each compartment door to be set up so compartment feed breaker must be open or defeated with screwdriver to open door.
4. Opening of RVSS or bypass starter compartment door will trip a door switch, this door switch trip contact will go to the process controller.
5. 120 VAC control circuits may remain energized when a section is open but a label shall so indicate.
6. The 120 VAC control circuit disconnect breaker shall be clearly labeled
7. Any 480 VAC terminals remaining hot with the PPS activated shall be coded and labeled as hot such as supply side of circuit breakers

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PROGRAMMABLE LOGIC CONTROLLER - RACK UNIT

The Programmable Controller shall have all the characteristics and features listed herein. All these features shall be readily available as an integral part of the Programmable Controller and shall be standard catalog items for the product. The use of any third party hardware or software add-on products to meet this specification is not acceptable. The L2000 Programmable Controller from Tesco Controls, Incorporated or preapproved equivalent is acceptable.

GENERAL REQUIREMENTS

Manufacturer

The Programmable Controller shall be procured from a manufacturer that has at least 10 years experience manufacturing its own Programmable Controllers designed specifically for the water and waste water industry. The Programmable Controller itself and support for the controller shall be available directly from the manufacturer. Programming services shall be available direct from the manufacturer as a normal practice. The manufacturer shall also produce a Supervisory Control and Data Acquisition (SCADA) system that integrates directly with the Programmable Controller, supporting the controller's native communications protocol, to take full advantage of its capabilities.

Warranty

The Programmable Controller manufacturer shall provide a 1 year warranty with the unit. A 5 year warranty and a 10 year warranty shall be available at additional cost. These warranties shall be available in writing directly from the manufacturer before bid acceptance. A warranty or service contract from a source other than the Programmable Controller manufacturer is not an acceptable substitute. The warranty shall provide for direct on-site replacement of the entire plug-in Programmable Controller, complete with the original program and configuration. The manufacturer shall provide personnel to perform the warranty service, at no additional cost to the purchaser. The replacement controller shall be available within 24 hours, installed and running at the station, without requiring that the original unit first be removed and returned to the factory.

Telephone Support

The Programmable Controller manufacturer shall provide telephone support for questions related to any aspect of the controller, including general use, application-specific issues, programming, and use of the programming software. This support shall be available directly from the manufacturer at no extra charge with the purchase of a controller.

Construction

The Programmable Controller should be constructed using a card cage architecture incorporating a 96 pin 3U DIN VME standard backplane interconnection. The printed circuit cards shall be designed to slide into the card rack and interconnect with the VME backplane. A high density I/O card with a mix of I/O types as well as an I/O card for each individual I/O type shall be available. The system shall operate with a minimum of 2 cards and shall be easily expandable to 20 cards. The Programmable Controller shall be solidly mountable, but shall be capable of being removed easily in the field. Card cages with a capacity of 2 to 20 slots shall be readily available. All field wiring to the I/O cards shall be done at externally mounted terminal blocks with ribbon cable interconnects to the relative I/O card.

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Operating Conditions

The Programmable Controller shall operate correctly under an ambient temperature range of -40 to +200 degrees F without requiring forced air or other special cooling measures. Coatings on connectors, component leads, and other materials used in the construction of the Programmable Controller shall be substantially resistant to atmospheres containing significant amounts of Hydrogen Sulfide gas and Chlorine gas. Each component shall have passed testing and be certified in writing by the manufacturer to be acceptable for use in water treatment and waste water treatment environments.

Other

The Programmable Controller shall have a low-power shut-down mode suitable for use in solar or other sites where power consumption is critical.
The Programmable Controller shall be provided with a complete operations and maintenance manual.
At minimum, each Programmable Controller shall be subjected by the manufacturer to a 5 day burn-in procedure at 165 degrees F.

CARD ARCHITECHTURE

Processor Card

The Programmable Controller shall be microcontroller-based, using a microcontroller that, at minimum, supports the following:
55/33 MHz clock rate
Flat (non-segmented) memory addressing
RISC Communication Co-Processor
Serial DMA channels
Dual-ported RAM
Watchdog timer
4 configurable timers with interrupt capability
6 serial ports with separate baudrate generators
Write-protect enable/disable

The Programmable Controller shall use a real-time, preemptive, multitasking operating system, contained in Read Only Memory (ROM). The ROM shall also contain all firmware that is not specific to a particular job or application, such as operator interface and communications firmware.
Application-specific programming and data shall be contained in battery-backed RAM. The RAM shall be low standby power, CMOS static RAM. The backup battery shall maintain RAM contents when the Programmable Controller is not connected to an external power source. The backup battery shall be a Lithium cell capable of continuously powering the RAM in a standby state for a minimum of 10 years with no loss of data. The Programmable Controller shall be available with a total of at least 1 megabytes of RAM.
The RAM shall be divided into two sections - write-protected, and non write-protected. The boundary between these two sections shall be user definable.

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Critical information, including the application program, control constants (setpoints), and configuration information shall be stored in write-protected RAM. The controlling of write-protected RAM shall be an integral feature of the microcontroller allowing writes to the write-protected memory only after a proper registration sequence. The Programmable Controller shall contain a watchdog timer circuit that will reset the microcontroller within 1 second of detecting a firmware failure. To provide a means of checking data integrity, the Programmable Controller shall compute a CRC-16 value on the contents of write-protected RAM whenever the data is changed and store the CRC value in a reserved location of write-protected RAM. An ongoing self test process shall periodically recompute the CRC and check it against the stored CRC during normal operation. Non write-protected RAM shall be used as a scratch area to hold temporary information and data values that are subject to constant change.
A dedicated TELCO style communications port shall be readily available for maintenance port operations using a laptop computer. Up to five additional communication ports shall be available for telemetry operations. A fault relay connector shall be readily available to provide closed contacts in the event of an internal failure or power loss.

High Density Input/Output Card
The Programmable Controller shall support the following high density card with the listed characteristics:
Analog input: senses voltage or current (selectable for 0-5V or 4-20 mA)
minimum 12-bit resolution
differential, isolated
available with at least 6
Analog output: sources voltage or regulates current (selectable for 0-5V or 4-20 mA)
minimum 12-bit resolution
differential, isolated in current mode
available with at least 2
Digital input: senses a contact open/closed condition
7500 V optically isolated
LED annunciators for each input on card faceplate
available with at least 16
Digital output: 10A relay contact
LED annunciators for each output on card faceplate
available with at least 8

Sequence of Events Card
The Programmable Controller shall support the following SOE card with the listed characteristics:
Digital input: senses a contact open/closed condition
event timestamp accuracy to 1mS, user defined event window
sequence of events reporting
7500 V optically isolated
LED annunciators for each input on card faceplate
available with at least 16
Digital output: 10A relay contact

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LED annunciators for each output on card faceplate
available with at least 16

Analog Input Card
The Programmable Controller shall support the following analog input card with the listed characteristics:

Analog input: senses voltage or current (selectable for 0-5V or 4-20 mA)
minimum 12-bit resolution
differential, isolated
available with at least 16

Analog Output Card
The Programmable Controller shall support the following analog output card with the listed characteristics:

Analog output: sources voltage or regulates current (selectable for 0-5V or 4-20 mA)
minimum 12-bit resolution
differential, isolated in current mode
available with at least 8

Digital Input Card
The Programmable Controller shall support the following digital input card with the listed characteristics:

Digital input: senses a contact open/closed condition
7500 V optically isolated
LED annunciators for each input on card faceplate
available with at least 32

Digital Output Card
The Programmable Controller shall support the following digital output card with the listed characteristics:
Digital output: 10A relay contact
LED annunciators for each output on card faceplate
available with at least 32

Input/Output Characteristics
The Programmable Controller shall provide built-in digital filtering of analog inputs. The filter constants shall be adjustable from the keyboard and through the communications ports. Each analog input shall have an independent filter constant. The Programmable Controller shall provide a virtually infinitely variable wide range of adjustment from no filtering to extreme filtering. Each analog output shall have the ability to maintain output or zero output when entering standby mode. Each digital output shall be turned off when entering standby mode.

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Field Wiring Terminal Blocks

The terminal blocks shall support the following listed characteristics:
pull-apart two piece wiring blocks for fast and easy wiring/re-wiring
separate wiring blocks for each I/O type and each wire point fully labeled
versatile internal or external analog power source
digital outputs shall have socketed 10A relays with LED "ON" indicators
entire terminal block shall snap on/off standard track mount
onboard passive circuit protection to protect programmable controller
shall be available with a built-in isolated current loop power supply, powered from the 12V DC main power. The current loop power supply shall be capable of producing at least 24V DC and 161 mA.
3 distinct classes of lightning protection shall be available:

Standard Class A lightning protection shall consist of
dual MOVs at each AI/AO
individually fused AI/AO power source
fused DI source and common with clamping diodes
onboard spare fuses for all fuse types

Class AA lightning protection shall, in addition to Class A, include
dual gas discharge tube at each AI/AO

Class AAA lightning protection shall offer the most comprehensive protection
full 500 joule 12 stage lightning protection at each AI/AO

Power Supply

The Programmable Controller shall be powered by a 12V/5V DC power supply, with an allowed operating range of at least +/- 10%. A 12V battery backup of the 12V DC shall be available such that the 5V DC is also maintained by the 12V battery.

OPERATOR INTERFACE

The Programmable Controller shall be available with the choice of at least two operator interface units that easily flush-mount in the enclosure door.
The compact model shall have at least the following attributes:

60 *Brite Lite* LED annunciators with adjacent site-specific label descriptions
8 *Brite Lite* LED mode annunciators and communication activity annunciators
8 character *Brite Lite* alphanumeric display of at least 0.5 inches high
4 keys to easily traverse a user-friendly menu tree that allows full control of operation
4 user-programmed macro keys with adjacent site specific label descriptions

The full display model shall have at least the following attributes:

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360 *Brite Lite* LED annunciators with adjacent site-specific label descriptions
8 character *Brite Lite* alphanumeric display of at least 0.5 inches high
4 keys to easily traverse a user-friendly menu tree that allows full control of operation
32 keys for full front panel programming
4 user-programmed macro keys with adjacent site specific label descriptions

The operator interfaces and site specific nomenclature and labels shall be completely covered with a mylar overlay that is impervious to corrosive atmospheres and wash-down environments.

Keyboard

The keyboard construction shall be sealed membrane type, using a stainless steel backing plate, and shall be impervious to atmospheres containing Hydrogen Sulfide and Chlorine gases. The keys shall provide tactile feedback. Both keyboard options shall provide a menu-based operator interface, allowing the operator to perform at least these functions, without process interruption:
Examine and change setpoints
Examine analog input and output registers
Examine and change timers and counters
Examine and change analog input filter constants
Calibrate analog inputs and outputs
Force digital outputs on and off
Override analog inputs and outputs
Examine control program

The full keyboard shall, in addition, allow the operator the ability to change the control program, and provide direct access to major functions without the use of menus. Either keyboard shall be available with at least 4 macro function keys. These macro keys shall be programmable to perform actions that would normally require multiple keystrokes on the normal keyboards. The programming shall be supported both by downloading through a communication port, and directly through the full keyboard.

LED Character Display

The Programmable Controller shall be available with an alphanumeric *Brite Lite* LED display capable of displaying at least 8 characters at a time using at least 15 segments per character. This display shall be at least 0.5 inches in height and shall be readable from a distance of at least 25 feet. The LED character display shall be used for showing the values of registers, inputs, outputs and other data. It shall also be used to display English language menu options to implement the menu system described above.

LED Annunciators

The Programmable Controller shall be available with individual *Brite Lite* LED's arranged in columns, which shall be usable to display the on/off state of digital inputs and outputs (physical or internal). The LED's shall also be usable for bar graph displays. The mapping of LED's to digital inputs and outputs shall be completely configurable, allowing any random arrangement, including

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the ability to map any number of LED's to a single input or output to achieve maximum visibility.

Mode LED's

The Programmable Controller shall be equipped with at least the following mode display *Brite Lite* LED's:

SBY lighted when in standby mode
CMD lighted when in command mode
RUN lighted when in run mode
MEM lighted when write-protected memory is open
CAL lighted when in calibration mode
XMT lighted when a message is being transmitted via a communications port
RCV lighted when a message is received via a communications port
ERR lighted when a an error condition is detected by the controller

The XMT/RCV LED's shall be configurable to selectively show activity on any combination of the communications ports.

Bar Graph Displays

The Programmable Controller shall have the ability to display at least 4 bar graphs on the *Brite Lite* LED annunciators. The bar graphs shall be individually configurable with respect to the following characteristics:

Display position (anywhere on the 380 LED's)
Height (allowing a range of at least 10-80 LED's)
Value to be displayed (allowing any analog input or output register scale)
Values representing the low point and high point of the bar graph scale in engineering units

Each bar graph shall allow up to 4 markers to be displayed to show a related value. Each marker shall be assignable to any setpoint, analog input, or analog output register, such that when the value of the register changes, the position of the marker shown on the bar graph changes appropriately. The markers shall flash in order to be discernible from the rest of the bar graph display. If the value being monitored by the bar graph should go beyond the defined endpoints (under range or over range), the LED at that end of the bar graph shall flash to indicate the condition.

OPERATING MODES

The Programmable Controller shall have two basic modes of operation as described below:

RUN:
Actively controlling, running application-specific control program
Sensing input signals
Generating outputs under program control
Peer-to-peer message initiation is enabled
Polling is enabled

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STANDBY:
Not actively controlling, application-specific control program is stopped
Continues to sense input signals
Analog outputs held at current level or set to zero
Digital outputs go to off state
Initiation of peer-to-peer messages is disabled
Polling is disabled

PROGRAMMING

Language

The Programmable Controller shall be programmable using the IEC 1131-3 "Standard for Automation Programming Languages" which includes a full implementation of the following five languages:

- Sequential Function Chart
- Structured Text
- Instruction List
- Function Block Diagram
- Ladder Diagram

The IEC 1131-3 program development environment shall at a minimum include the following features:

- Native Microsoft Windows Application
- Operate on a PC platform running Microsoft Windows 3.11/95/NT
- Allow Upload/Download of all program code
- Full Graphic Editor Tools optimized for creating and editing source programs
- Animated Graphic Tools
- Off-Line Simulation Tools
- On-Line Debugger Tools
- Documentation Tools
- Archive Tools
- Library Management Tools
- Project Management Tools
- Password Protection Tools for Projects and Libraries

In addition to the above IEC 1131-3 languages the controller shall have the ability to execute compiled C++ source code and also the ability to execute a higher-level BASIC-like programming language which is native to the controller.

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The native programming language shall at the least support the following attributes:
The programming language shall be line number oriented, with an allowed range of line numbers of at least 65,000. The language shall support the ability to:
Event subroutines that execute automatically upon change of input signal
Create multiple execution loops within the program
Create multiple subroutines
Nest subroutines to at least 10 levels
Make a direct jump to a specified line number
Use built-in math functions, including log, inverse log, sine, cosine, tangent, min, max
Use parenthesis to specify precedence in expression evaluation, nested to at least 10 levels
Use indirection in register reference, where the specific register number referred to in an expression is stored in another register
Execute code segments based on specified events that are monitored by the operating system to ensure immediate response to critical events. The Programmable Controller shall support the definition of at least 25 individual events. These events shall be definable as:
Change of state on a digital input or output
Logical truth condition of an arbitrary expression involving any register type (such as "ANALOG INPUT 7 > SETPOINT 17 + SETPOINT 18")

Registers

The Programmable Controller shall have at least the following preformatted register types arranged in a global system database, with the quantity of each register type selectable to at least the numbers given:
Setpoint (for storing constants, at least 1000)
Analog input (physical or internal, at least 1000 total)
Analog output (physical or internal, at least 1000 total)
Digital input (physical or internal, at least 1000 total)
Digital output (physical, at least 64)
Index (for indirection and general purpose use, at least 1000)
Timer/counter (at least 1000 total)
The Programmable Controller shall store setpoint, analog input and analog output registers in 32-bit precision IEEE 754 standard format, providing the ability to represent numbers in the range +/- 3.37 x 1038. Index registers shall be stored as 32-bit precision unsigned integer values, providing the ability to represent numbers in the range 0 to 4,294,967,295. Timer/counter registers shall be stored as 32-bit precision unsigned values, supporting at least the following sub-types:
Seconds timer (times in seconds with 10 mS or better resolution, up to 497 days)
Hours timer (times in hours with 2 second or better resolution, up to 272 years)
HMS timer (hours, minutes, seconds format, with 0.5 second or better resolution, up to 68 years)
Event counter (integer value register supporting increment/decrement, range 0 - 4,294,967,295)
The Programmable Controller shall provide a counter type that may be associated with one of the 16 interrupt-driven digital inputs, in order to count pulse trains. The Programmable Controller shall support a pulse counting frequency of at least 1 kHz on a single input.

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The Programmable Controller shall provide a timer type that may be associated with digital outputs, in order to produce variable duration output pulses. The range of pulse durations shall be at least 20 mS to 994 days, with 20 mS resolution.

PID Function

The Programmable Controller shall provide built-in PID (Proportional/Integral/Derivative) control without requiring any procedural programming or subroutine writing. The PID setup shall be table-driven, allowing the designation of registers for the PID input and output parameters and variables. The PID control routine shall be automatically executed by the operating system as a background task whenever the Programmable Controller is in Run mode. The Programmable Controller shall support the ability to simultaneously execute at least 16 independent PID control loops.

CONFIGURATION

The Programmable Controller shall be configurable via a configuration table, which shall be changeable both by downloading through a communication port and through the full and limited keyboards. The configuration table shall allow the operator to change virtually all significant operating parameters of the system, including:
Number of physical and internal registers of each type
Input scan rate, selectable in 1 mS resolution or better
Individual filter constants for pulse counting on each of the 16 interrupt driven digital inputs
Event logging levels for each different output device capable of reporting events, including the alphanumeric display, and RAM event log
Maximum number of messages to store in the RAM event log
Speed with which messages are scrolled across the alphanumeric display
Default precision for floating point number displays
Which ports (1,2,3,4... or any combination) are shown on the transmit and receive activity LED's
Time from last key press until unit automatically logs out the user, including a setting that will disable the automatic log out feature
Ethernet/IEEE 802.3 (10Mbps)
DeviceNet Industrial Network (500K baud)
Serial Communications port parameters, including:
Personality (at least: RS-232 full handshake, RS-232 no handshake, RS-485, direct modem, radio modem, dialup modem)
Baud rate (110 to 230,400)
Parity (odd, even, none)
Stop bits (1,2)
Use of DCD handshake signal for point to point versus multi-point telemetry
Port timing parameters (in 10 mS resolution), including:
Delay from receipt of message to attempted response (0 - 10 seconds)
Leading pad bytes (0 - 20 pad bytes)
Trailing pad bytes (0 - 20 pad bytes)
Time to wait for acknowledge of transmitted message (0.01 - 10 seconds)
Maximum number of times to try transmitting when no acknowledge received (1 - 65,535)

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Time to wait before retrying transmission when encountering a line busy condition (0.01 - 40,000 seconds)
Maximum number of times to try transmitting when encountering a line busy condition (1 - 65,535)
Time to wait to try to reconnect to a unit that has failed to respond (0.01 - 40,000 seconds)
Receive and transmit buffer sizes
Transmit queue size
Unit to attempt to notify of communications failures on this port

COMMUNICATIONS

The Programmable Controller shall have the ability to simultaneously support at least 4 serial communication ports which includes an Ethernet/IEEE 802.3 and a DeviceNet industrial network. Any of these serial ports shall be usable for both communications of telemetry data and control program/configuration upload/download and support baud rates of 230,400 bps or higher. The ports shall be configurable to support the following media:
Full handshake RS-232 (at least 3 ports must be configurable this way)
RS-485 (at least 3 ports must be configurable this way, selectable for 2/4-wire)
Direct Modem available with radio interface, supporting Bell 202 standard

Protocols

The Programmable Controller shall implement the Ethernet/IEEE 802.3 protocol. When the Programmable Controller wishes to transmit, it will check for activity on the LAN. When the LAN becomes silent for a specified period, the Programmable Controller will begin transmission. During transmission, the Programmable Controller will continually check for a collision on the LAN. If a collision is detected, the Programmable Controller will cease transmission. The Programmable Controller will then wait a random period of time before attempting to transmit again.
The Programmable Controller shall support a DeviceNet Industrial Network. This device level Industrial network will enable the Programmable Controller to communicate to devices such as sensors, switches, relays, contactors, and control valves.
The Programmable Controller shall support serial communications using at least 3 different protocols. The de facto standard ModBus protocol shall be supported. The Programmable Controller shall also support a protocol capable of taking advantage of the advanced features available in the Programmable Controller (that ModBus would not be able to support). These protocols shall be able to coexist simultaneously on the same port.
The Programmable Controller shall support poll/response, polling master, quiescent, report-by-exception and message routing communications, as described in the following sections. Any of these communications modes shall be usable alone or simultaneously in any combination.

Polled Slave Communications

The Programmable Controller shall respond as a slave unit in response to polling messages from a master SCADA system or other unit. In this mode the Programmable Controller shall only respond to requests for data and not initiate messages on its own. Transmission of all register types shall be supported.

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Polling Master Communications
The Programmable Controller shall initiate polls as a master unit and wait for the response from the slave device. Polling of all register types shall be supported. Polling communications shall be configured via a table such that listed registers may be polled for from a slave programmable controller or other system based on an elapsed time interval. The polled values shall be storable in any analog input, output or setpoint registers. This table shall be downloadable via a communication port.

Quiescent Communications
Using quiescent (peer-to-peer) communications, the Programmable Controller shall provide the ability to initiate messages transmitting register values under operator definable conditions. Quiescent communications operation shall be configured via a table such that listed registers may be sent to a peer programmable controller or other system based on an elapsed time interval, a change of state, or change by a threshold amount. The threshold values shall be storable in any analog input, output or setpoint registers. This table shall be downloadable via a communication port.

Report by Exception Communications
The Programmable Controller shall support a means of report-by-exception communications, where only those registers of interest that have changed since the last reporting are transmitted. All register types shall be supported. The Programmable Controller shall use a table to identify the registers that are to be transmitted via report-by-exception and individual thresholds that are used to determine significant change. This table shall be downloadable via a communication port.

Message Routing
The Programmable Controller shall provide the ability to route received messages that are destined for another unit. The routed message can be received and sent in any combination of communication ports and physical media. Using this method the controller shall provide the ability to transfer messages between two or more units that are not directly connected, but that are both connected to the routing controller.

Failure Recovery
The Programmable Controller shall have the ability to switch to alternate communications paths in the event of failure of the primary path. There shall be no practical limit on the number of different paths that the Programmable Controller may try in order to deliver the information. These alternate paths shall be definable to be a different destination unit on the same port, or the same or different unit on a different port. In the event that the original communications path becomes available again, the Programmable Controller shall switch back to that path.

Redundant Message Elimination
The Programmable Controller shall automatically provide redundant message elimination when peer-to-peer and polled communications are used in combination. When a value is polled for and that same value is due to be reported via peer-to-peer communications, the conditions in the Programmable Controller shall be reset such that the peer-to-peer message doesn't immediately report the same information, but instead waits for the value to cross the threshold again, or pass the time interval.

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Other

The Programmable Controller shall provide a means of enabling/disabling quiescent/polling master message initiation from the keyboard. The Programmable Controller shall provide a means of monitoring message traffic via the alphanumeric display, showing source and destination addresses and message codes represented in mnemonic form. The monitor display shall show messages directed to any unit on the communications network. Any key press shall temporarily disable this monitor display for a period of 5 seconds.

ENGINEERING UNIT REPRESENTATION

The Programmable Controller shall have the capability to represent all analog input and analog output values directly in engineering units. Engineering units are defined to be "real world" IEEE 754 standard floating point numbers corresponding to physical measurements, such as pressure, depth and flow. The Programmable Controller shall not require the operator to manipulate analog inputs and analog outputs in terms of the "raw" 12-bit (0-4095) data corresponding directly to the analog-to-digital and digital-to-analog converters. To provide engineering unit representation, the Programmable Controller shall not require the use of any additional registers or require that a program statement, formula or any expression be written to convert raw data to engineering units. Telemetry communications shall use engineering unit representation in all messages.

CALIBRATION AND MULTI-POINT CALIBRATION

A simple menu-driven procedure shall be provided that allows the operator to calibrate an analog input or output to an engineering unit measurement scale. This procedure shall be usable from both the full and minimal keyboards. The calibration information shall be uploadable/downloadable via a communication port.

In calibrating an analog input/output, the Programmable Controller shall allow the operator to select points along the response curve of the input/output device and assign them a corresponding engineering unit value. The Programmable Controller shall allow the operator to use up to 16 calibration points in order to account for non-linearities in the response of the attached input/output device. During the calibration process, the Programmable Controller shall display the value of the actual signal on the input/output in terms of milliamps or volts, depending on how the input/output is configured. For an analog input, the Programmable Controller shall also allow the operator to perform a rough calibration without actual signal values on the input, by manually selecting simulated voltage or current values.

SINGLE AND MULTI-POINT TEST

The Programmable Controller shall provide the ability to override register values for test and other purposes. The following registers shall support this test override feature:

Analog input
Analog output
Digital input
Digital output
Timer/counter
Index register

When in override, the operator shall be able to control the register (set any value or on/off state) independent of the control program or physical input. The value seen by the control program shall be the override value.

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The Programmable Controller shall provide two separate override functions - single-point and multi-point. The two functions shall be separately assignable privileges by password. The single point override function shall allow the operator to override a single register. When he exits this function to perform other operations, the override shall be automatically released. The multi-point override shall allow the operator to lock in at least 100 individual overrides. He shall be able to exit the override function and perform all other normal functions on the Programmable Controller, with the override points remaining locked in their selected states. The Programmable Controller shall provide the ability to individually release override points based on a list of current points presented to the operator. The operator shall also be able to release all override points at once. When any register is in override, there shall be a visible indication to the operator, regardless of what mode the Programmable Controller is in.

ALARMS

The Programmable Controller shall provide alarm flags to be used to indicate application-specific alarm conditions. Alarms shall have the following functionality:
Adherence to ISA Sequence M standard
Any digital input or digital output (physical or internal) may be designated as an alarm
The alarm may be independently mapped to any LED annunciator
When the alarm condition is asserted the associated LED shall flash
It shall be individually selectable if the physical output for a digital output alarm will turn on and off with the LED or stay on solid when the alarm is asserted
If the alarm is acknowledged, the LED shall go solid on if the alarm condition still exists, or solid off if the condition no longer exists
If the alarm condition goes away before the alarm is acknowledged, the LED shall continue to flash until acknowledged
The Programmable Controller shall provide at least these methods of acknowledging alarms:
Through the full keyboard with a single key
Through the minimal keyboard with a menu function
Using any digital input, designated by the operator
The Programmable Controller shall provide a common alarm digital output, that can be configured to be any digital output and can be displayed anywhere on the LED annunciators. The common alarm LED shall flash whenever there are any unacknowledged alarms. It shall be configurable whether or not the physical output follows the on/off cycle of the LED or stays on solid when the common alarm is active.

FAULT TOLERANCE AND RELIABILITY

Event Logging

The Programmable Controller shall provide a mechanism that reports and logs unusual events and items of interest. Events shall be classified into at least these categories:
Fatal Error - a severe error that may compromise system integrity
Error - an error condition that aborts the involved function, but does not compromise system integrity
Warning - a potential problem that is recoverable
Informational - something the operator might be interested in, not a problem

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Upon the detection of an event, the Programmable Controller shall report information about the event, including date, time to 10 mS resolution, the reporting agent or function, and the nature of the event. If a Fatal Error event is detected, the Programmable Controller shall automatically reset itself, reinitializing the operating system and all system functions. Events shall be directable to any combination of one or more of the following devices: the alphanumeric display, the LCD display, and the RAM event log. The minimum event severity reported shall be individually definable for each output device. The RAM event log shall store the list of reported events, with the number of messages stored being a configurable item. The Programmable Controller shall support viewing of the RAM event log data by transmission via the serial port.

Fault Relay

The Programmable Controller shall contain a normally closed fault relay that under normal operation shall be energized by the Programmable Controller to indicate a non-fault state. The fault relay shall go to a fault condition (non-energized) under the following circumstances:
12 V DC power failure
Memory error or other internal operating error

Power Up Self Test

The Programmable Controller shall perform a brief self test upon application of power, including:
ROM checksum
RAM write-protection circuit check
Write-protected RAM CRC check

On Going Self Test

During normal operation (run or standby modes) the Programmable Controller shall run an ongoing self test process that periodically checks the following:
Write-protected RAM integrity (CRC)
The frequency with which the ongoing self test performs these checks shall be configurable by the operator.

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Diagnostic Functions

The Programmable Controller shall have the capability to perform self-test diagnostic functions under operator control to verify the integrity of the unit. These tests shall include as a minimum:
ROM Test - check the validity of the ROM contents, using a checksum
Write-Protected RAM Test - checks each address in write-protected RAM for ability to write and read properly; shall support repetitive test mode that runs continuously and tallies the results
Non Write-Protected RAM Test - just like above test, but checks non write-protected RAM
Annunciator Test - flashes all annunciators on and off repetitively to verify that each LED works properly; physical digital outputs shall be unaffected during this test
Voltage Test - displays voltage on RAM backup battery, 12 V DC main supply, and CPU operating supply
Communications Port - tests each port individually, sending out a test pattern and verifying its return; shall support both internal and external loop back of the signal, and repetitive test mode that runs continuously and tallies the results
Network Test - sends a test message to a remote unit, selectable by the operator; provides a means of repetitively sending the test message, at a frequency determined by the operator; waits for a response and tallies the results

Activity Monitoring

The Programmable Controller shall provide a mechanism for selectively viewing activity of certain integral subsystems. Text messages indicating activity shall be directable under operator control to the LCD or a communication port. The subsystems that can be monitored shall include:
Input scanning (showing raw and calibrated values)
Serial port communications
Ongoing self test
The serial communications monitoring shall have the following capabilities:
The ability to monitor any combination of the 6 ports
Date and time stamping of each message to 10 mS resolution
Selectively show only messages directed to and sent by this unit, or all messages
Three non-exclusive modes:
1) raw byte display in hexadecimal
2) interpreted mode where messages are displayed by acronym
3) transmission queue mode that shows each change to the queue

Power Fail/Brownout Detector

The Programmable Controller shall have an integral hardware device that detects a brownout or imminent power fail condition. Upon detection of the 12V DC power supply voltage dropping below an adjustable threshold, this device shall generate an immediate interrupt signal to the microcontroller. The microcontroller shall respond to this interrupt by finishing any memory write operations in progress, then going into a safe execution loop where no memory write operations are occurring.

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Watchdog Timer

The Programmable Controller shall contain a hardware watchdog timer circuit that will reset the microcontroller within 1 second of detecting a firmware failure.

SECURITY

The Programmable Controller shall be capable of being configured to require password entry before access to functions that would change the control characteristics or basic operating mode (run/standby) of the Programmable Controller. Multiple passwords shall be supported, with at least 100 allowed. Each password shall allow an independent set of privileges. A default list of privileges shall be definable that apply when no operator has unlocked the Programmable Controller with his password. If the operator does not operate the keyboard within a selectable time period, the Programmable Controller shall log him out automatically. At least the following functions shall be individually assignable privileges:

Examine Analog Input
Examine Analog Output
Examine Digital Input
Examine Digital Output
Examine Setpoint
Examine Timer/Counter
Examine Index Register
Examine Filter Constant
Examine Program
Examine Configuration
Examine Archives
Change and Setup Archives
Change Operating Mode (Run/Standby)
Perform Single Point Test Override
Perform Multi-Point Test Override
Acknowledge Alarms
Change Setpoint
Change Filter Constant
Change Calibration
Change Configuration
Perform Diagnostics
Administer Passwords

Passwords shall be maintainable from both the full and minimal keyboards, if the operator has the Administer Passwords privilege. He shall be able to:

View the list of existing passwords
View the privileges for a given password

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Change a password
Add a password
Add/remove privileges from a password
Delete a password

The Programmable Controller shall also support uploading and downloading of password configuration information via the communications ports.

DATA ARCHIVING

The Programmable Controller shall provide a means of archiving register values into storage arrays. The register types that may be archived shall include:
Analog input
Analog output
Digital input
Digital output
For analog inputs and outputs, the Programmable Controller shall implement archiving using a data compression scheme such that each point stored represents the minimum, maximum, and average over the previous sample period. The sample period shall be configurable, allowing a range of at least 1 minute to 15 minutes. The Programmable Controller shall collect multiple samples, evenly spaced in time, within the sample period. The sample rate shall be configurable, allowing a range of at least 1 to 10 seconds. A second method of sampling shall be supported for analog inputs and outputs, where the data value is stored whenever it crosses a threshold from the previously stored value. The threshold shall be stored in a selectable analog input, output, or setpoint register. Digital inputs and outputs shall be stored upon change of state.

The Programmable Controller shall allow the operator to define at least 25 separate registers to be archived, with individual timing and threshold parameters for each.

The Programmable Controller shall provide direct read access through any communications port to the contents of each data archive. Each sample shall consist of a date and time stamp and the register value. The Programmable Controller shall also provide functions available through the communications port that allow an external SCADA or other system to reset specific archives and obtain other necessary information about the data archives in use.

REMOTE CONRTOL

The Programmable Controller shall have the ability to remotely control other controllers of the same make using any of the communication ports. The operator shall be able to perform at least the following functions on the remote unit by using the local keyboard:

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Examine and change setpoints
Examine analog input and output registers
Examine and change timers and counters
Force digital outputs on and off
Override analog inputs and outputs
Change operating mode between Run and Standby

PROGRAMMING SOFTWARE

A free copy of the native language programming software shall be provided with each Programmable Controller purchased. The software shall be produced, provided and supported directly by the Programmable Controller manufacturer. No third party tools are acceptable. This software tool shall:
Execute on an industry standard IBM-compatible PC
Execute under Microsoft Windows NT and Windows 95
Windows NT 32 Bit Multi-Threaded/MDI Application
Project Management capabilities
Communicates over existing telemetry communications paths
Real Time Polling and onscreen variable updates
Perform upload and download of all tables needed to configure the Programmable Controller
Provide a batch upload and download feature to transfer multiple selected tables
Perform any program assembly/disassembly functions and cross-references required
Open files and selected directory from last session and present these upon restarting program
Provide context-sensitive help
Allow the user to change the operating mode (run/standby) of the Programmable Controller
Allow the user to read and set the Programmable Controller real time clock

QuickLoad Software

A fast and easy to use software program shall be available free of charge to Upload and Download from a laptop computer to the controller all calibration points, setpoints and native control programming.
A complete user's manual shall be provided which describes the use of all programming software.

Windows DDE Server Software

A windows DDE server program shall be available to poll the programmable controller and serve real-time data values to any DDE compliant client, such as spreadsheets, databases and SCADA systems. This software shall operate on a laptop computer and shall poll the controller through the maintenance port to gather real-time data of any type and number. Also, the program shall operate remotely through a POTS dialup phoneline to poll for any real-time data in the controller. The program shall have the ability to operate in a multipoint controller environment, up to 100 controllers, with full hardware handshaking to the communications media. The program shall have the ability to display all telemetry message transactions for the communications port and shall utilize protocol disciplines such as retries, comm failures and automatic comm recovery methods.

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REACTIVE AIR MONITORING LEVEL SYSTEM

The level monitoring shall be done by a reactive air system consisting of an air compressor, compression bell, 3-way solenoid valve, and level transducer. The level transducer senses the back pressure of the static air column set up in the compression bell that is periodically replenished by the purge air compressor. The compression bell shall be designed with high strength non-corrosive plastics and shaped to provide a resistance to buildup of foreign material. The specially designed programmed multi-cycle cleaning system shall prevent the compression bell from plugging while minimizing compressor run time. The reactive air control shall also provide a means of manually actuating the purging cycle when immediate purging and cleaning is necessary.

The purge sequence shall be as follows:

a) The 3-way valve is sequenced to the purge position by the controller's purge mode automatically every 8 hours (adjustable). While in the purge mode the last level transducer value is electronically held by the hold circuit.

b) The compressor is then started to purge and clean the air lines and replenish the compression bell with a 50 PSI air blast. The air blast is retained for 4 seconds (adjustable).

c) The 3-way valve is held in the purge position an additional 4 seconds after the compressor is stopped to allow the air dynamics to settle.

d) The 3-way air valve is now transferred to the normal level monitoring position and the level transducer signal is held thru the purge cycle, plus 10 seconds, then released to reflect the real time level value.

e) The system is now recharged with a 30 day supply of air in the compression bell and the controller operation is back to normal mode.

Specifications:

Standard Level Range:	0-35ft.
Optional Level Ranges:	1 ft, 5 ft,12 ft,70 ft, 140 ft, 240 ft, 480ft
Operating Voltage:	120 VAC or 12 VDC
Temperature Range:	0 to 200 degrees Fahrenheit
Accuracy:	+/- 0.125 @ 35 ft.
Repeatability:	0.2%
Interface:	2-wire analog current loop, 4-20 mA
Compressor Type:	Oil-less, direct drive
Compressor Construction:	Aluminum piston, teflon-sleeved aluminum cylinder
Compressor Torque:	Initialize into 250 PSI head
Compressor Displacement:	0.65 CFM @ 50 PSI